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DRAWINGS ATTACHED

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(54) IMPROVEMENTS IN OR RELATING TO PROCESSES FOR MAKING BULKED YARNS BY THE FIBRILLATION OF THERMOPLASTIC FILMS

(71) We, HERCULES INCORPORATED, a corporation organized and existing under the laws of the State of Delaware, one of the United States of America, of 910 Market Street, City of Wilmington, State of Delaware, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to the fibrillation of thermoplastic films and particularly to the fibrillation of striated films to provide continuous filaments, and to the simultaneous crimping or bulking of the filaments.

In U.S. patent 3,457,611 there is disclosed a jet unit for bulking a yarn consisting of continuous filaments of a thermoplastic material, which unit comprises a bulking chamber that is open at one end and has a laterally moving screen-like member adjacent to and substantially closing the open end of the chamber. A fluid jet opens into the opposite end of the chamber and entrains a yarn to advance it onto the screen-like member. The fluid is at a temperature sufficient to soften the yarn without loss of orientation and the chamber is dimensioned relative to the jet to provide for limited lateral movement of the jet. The jet and thus the yarn is deflected laterally as it is advanced through the bulking chamber whereby the individual filaments of the yarn are folded onto the screen-like member, with the folds therein defining the crimps in the final yarn. The theory of operation in this device, which is not a limitation of the invention, is that, with the screen-like member substantially closing the open end of the chamber and the fluid jet confined to exhaust through the member, the fluid jet and thus the yarn are continuously diverted as the yarn tends to plug a portion of the screen-like member and the fluid jet and the yarn are diverted to another portion, which then in turn becomes plugged by the yarn to divert the same again.

In accordance with this invention, it has been found that the apparatus of the above noted patent is particularly adapted for simultaneously fibrillating a film of thermoplastic material and bulking the resulting filaments.

According to the present invention, there is provided a process for simultaneously fibrillating a film to form continuous filaments and bulking the resulting filaments, characterized by the steps of: providing a ribbon of longitudinally oriented thermoplastic film having striations extending lengthwise thereof in a parallel and equally spaced arrangement, with the striations interconnected laterally by webs of reduced thickness; feeding the ribbon endwise positively at a predetermined speed; forming a jet from a fluid at a temperature sufficient to soften the ribbon without loss of orientation, with the jet surrounding the ribbon and moving the same endwise therewith at a predetermined speed; directing the fluid jet and the ribbon into a chamber having an open end opposed to the fluid jet and a cross-sectional area sufficient to permit limited lateral movement of the fluid jet; and moving a screen at a speed substantially less than the above predetermined speed laterally across, and in close proximity to, the open end of the chamber for confining the fluid jet to exhaust from the chamber through the screen, whereby the ribbon is fibrillated into continuous filaments which are folded onto but unequally deposited on the screen, thereby diverting the fluid jet from the more dense to the less dense areas of filament deposition and resulting in deflection of the jet and thus the ribbon within the chamber in a random manner and at a rapid rate, and whereby the filaments on the screen are compressed against the screen as they are moved on the surface of the screen from the area of the chamber.

With a striated ribbon such as that disclosed in U.S. Patent 3,470,685, the web portions between the striations constitute lines of weakness whereby the ribbon fibrillates into continuous filaments corresponding to the striations. The fibrillation is preferably com-

plete so that each striation is separated from the adjacent triations to provide a single filament. With the apparatus disclosed in U.S. patent 3,457,611, the working of the ribbon in the chamber is sufficient to effect substantially complete fibrillation and effects the fibrillation before the crimping action to permit random crimping of each individual filament.

While the prior art includes disclosures of jet units for the simultaneous fibrillation and bulking of plastic films, see for example patent 3,402,548, such units have relied upon turbulence to provide both the fibrillation and the bulking of the film. In contrast, the present invention contemplates a lateral deflection or whipping of the jet at a rapid rate prior to bulking to provide fibrillation, after which the separated filaments are individually folded onto the screen-like member for crimping. Continuity of the process of this invention and the production of substantially uniform filaments is provided by using striated film which, upon fibrillation, is reduced to continuous filaments.

The present invention is hereinafter disclosed with reference to the accompanying drawings, in which:

Fig. 1 is a schematic illustration of apparatus for practicing the process of this invention.

Fig. 2 is a fragmentary sectional view of the jet units of the apparatus of Fig. 1.

Fig. 3 is a fragmentary portion of the plastic film that is used in the process of this invention.

Fig. 4 is a fragmentary portion of several of the filaments produced by the process of this invention.

With reference to the drawings, thermoplastic film is provided in the form of a striated ribbon R which consists of a plurality of striations S extending lengthwise of the ribbon in spaced parallel arrangement and interconnected laterally by webs W of reduced thickness. The ribbon R is oriented in the direction lengthwise of the striations S and therefore has little tensile strength laterally. The webs W constitute lines of weakness so that upon splitting longitudinally, the splitting will proceed along the webs and will not wander across the striations S. Thus, when the ribbon R is completely fibrillated, it will be reduced to individual filaments F, each of which consists of one of the striations S of the ribbon and a portion of the web W on each side thereof, with each of the web portions terminating in an edge E along which the web was split.

The apparatus illustrated in the drawings, which is substantially the same as that disclosed in the above identified U.S. patent 3,457,611, comprises a pair of feed rolls 1 which draw the ribbon R from a source (not shown) and feed it to a jet unit 2. As hereinafter discussed, within the jet unit 2 the ribbon R is fibrillated to provide a plurality of individual bulked filaments F which together constitute a yarn Y.

From the jet unit 2, the yarn Y is deposited on an endless screen 3 entrained about a pair of spaced rollers 4 and 5 and driven to advance the screen in the direction of the arrow A. The roll 4 is designed to support the screen 3 immediately beneath the jet unit 2 while permitting a bulking fluid to pass therethrough, and for this purpose may comprise corrugations arranged on edge radially of the roll 4 such as in the couch rolls of a fourdrinier machine. The yarn Y is pulled from the screen 3 by nip rolls 6 and, from there, passes to a winder (not shown).

The jet unit 2 comprises a jet body 8 having an axial bore 9 which includes a cylindrical portion 10 in the upper end of the bore 9 that leads into a downwardly converging portion consisting of an upper frustro-conical surface 11 and a lower frustro-conical surface 12 that is sharper or more acute relative to the axis of the jet body 8 than the surface 11. The bore 9 also includes what is herein called a capillary tube 13 and a bulking chamber 14, both of which are preferably cylindrical and which are disposed in turn at the output end of the surface 12 so that the capillary tube 13 constitutes in effect a nozzle opening into the bulking chamber 14.

Within the cylindrical portion 10 of the bore 9 there is mounted a tube 15 that is accurately positioned co-axially of the bore 9 by a pair of spaced positioning surfaces 16. The tip 17 of the tube 15 is frustro-conical with a cone angle corresponding to or slightly less than the cone angle of the lower frustro-conical surface 12 to provide a downwardly converging annular passage 18 between the same. The tube 15 is positioned endwise in the bore 9 by a flange 19 overlying the top surface 20 of a reduced and externally threaded upper portion 21 of the jet body 8. A cap 22 is provided with an internally threaded skirt 23 that is threaded onto the reduced upper portion 21 of the jet body 8 and has a cover portion 24 that overlies the flange 19 and compresses the same against the surface 20. A shim 25 is interposed between the flange 19 and the surface 20 to locate the tube 15 accurately endwise of the bore 9. The cap 22 has a thread eye 26 which directs the ribbon R into the bore 27 of the tube 15. The ribbon R will generally be bunched up to allow it to pass into the bore 27 the diameter of which is much smaller than the overall width of the ribbon R. Such bunching of the ribbon R generally presents no problem owing to the thinness of the webs W.

The outer diameter of the tube 15 is substantially smaller than the diameter of the cylindrical portion 10 of the bore 9 to provide an annular chamber 29 that communicates

with the annular passage 18. Bulking fluid, which is preferably steam, is supplied to the chamber 29 through a bore 30 in the jet body 8, which bore 30 connects with a bore 31 in a supporting arm 32 that carries the jet unit 2. The bore 31 is in turn connected by a flexible conduit 34 to a source of fluid under pressure (not shown).

The jet body 8 is positioned directly over the roller 4 with its bottom surface 35 and thus the exit of the bulking chamber 14 positioned immediately above the screen 3. The jet body 8 is secured by bolts 36 to one end of the supporting arm 32 which is pivotally mounted at its other end on a pivot rod 37 on an axis parallel to the axis of the roller 4. The jet body 8 is thus free to move about the axis of the pivot rod 37 toward and away from the screen 3. Pivotal movement of the jet unit 2 in the direction toward the screen 3 is limited by stop means comprising a bracket 38 (Fig. 1) secured to the jet body and a bracket 40 secured to a support 41. The jet unit 2 is biased to its stop position by gravity which, if necessary, may be supplemented by means such as an air cylinder 42 secured to the bracket 41 and having its piston bearing on the bracket 38.

Example

As an example of a specific process in accordance with this invention, there was provided a jet body 8 with a bulking chamber 14 having a diameter of 0.250" and a depth of 0.250". The capillary tube was 0.093" in diameter and 0.130" in length. The bore 27 of the tube 15 was 0.046" in diameter and the cone angle, that is, the included angle between the side walls at diametrically opposed points of the frustro-conical surface 12 and of the tip 17 of the tube 15 was 40°. The tube 15 was positioned endwise of the jet with the bottom edge thereof at the level of the input of the capillary tube 13. The stop means was adjusted to support the jet body 8 with the bottom surface thereof 0.005" off the screen 3. The jet body 8 was biased downwardly into its stop position by a total force of two pounds.

The feed rolls 1 were operated to feed the ribbon R at a rate of 460 feet per minute, while the screen 3 was operated at a surface speed of 133 feet per minute. The bulking fluid was saturated steam at 100 p.s.i., the temperature of which was 170° C.

A ribbon of polypropylene film was made by extruding a film strip two inches wide and having sixty-seven striations that were twelve mils in diameter and spaced at intervals of thirty mils, and interconnected by webs that were two mils thick. The as-extruded film strip was melt drawn at a ratio of four-to-one to a strip that was about one and one-half inches wide with striations having a thickness of about five mils. The melt-drawn film strip was oriented at a draw ratio of six-to-one to provide the ribbon R which had an overall width of about seven-tenths of an inch and in which the striations S had an average total thickness of about two mils and a gauge of about ten mils, and the webs W had an average thickness of about 0.45 mil.

The resulting product was substantially completely fibrillated using the above apparatus to provide individual continuous filaments F corresponding to the striations S in the ribbon R and having a random, three-dimensional crimp.

The following theory of operation is not intended as a limitation of the invention but is believed to be helpful in an understanding of it.

The fluid jet that issues from the capillary tube 13 into the bulking chamber 14, is moving at a high velocity relative to the ribbon R, which in turn is moving at a speed of for example over three times the speed of the screen 3. The jet surrounds and frictionally entrains the ribbon R to tension the same against the restraint imposed by the feed rolls 1 and thus advance the same at the speed determined by the feed rolls 1. The jet tends to travel in a straight line through the bulking chamber 14 and through the screen 3 to exhaust. However, as the ribbon R, which is being fed at a rate faster than it is being removed by the screen 3, accumulates on the screen, it forms an obstruction which deflects the jet laterally to a spot on the screen that is not obstructed by an accumulation of the ribbon. When the jet is deflected, the ribbon R which is entrained by the jet is deflected with it.

The ribbon R, or the filaments F to which it has been reduced, are carried by the screen 3 as it is advanced and are thus compressed and clamped between the screen 3 and the bottom surface 35 of the jet unit 2. Insofar as the length of a filament F from the clamped point to the exit of the capillary tube 13 is sufficient to accommodate it, the filament will follow the jet as it is deflected. This will include lifting the filament off the screen 3 at a point where it may have been deposited but not yet clamped whenever the jet is deflected to another point which would involve a longer path for that filament. Eventually there is an excess of the filament in the chamber 14 so that no lateral movement of the fluid jet will define a yarn path long enough to require lifting the filaments from the screen. This filament is thus finally deposited on and carried out of the chamber by the screen 3.

The excess lengths of the filaments F or the ribbon R in the bulking chamber 14 cause the jet to be continuously deflected at a very rapid rate since, when the jet is deflected to a substantially unobstructed portion of the screen 3 it moves these excess lengths to the

new portion of the screen so that the new portion of the screen thus becomes obstructed and the jet is again deflected. The endwise advance of the ribbon R is very slow relative to the rate at which it is deflected laterally so that the ribbon is repeatedly worked or whipped about in the chamber 14 and thereby split along the webs W to provide filaments F. The repeated working of the ribbon R as it is shifted back and forth laterally and laid onto and lifted from the screen 3 exposes the ribbon in virtually every conceivable orientation relative to the fluid jet, and insures substantially complete fibrillation of it.

Random crimping of each individual filament F requires complete fibrillation of the ribbon R prior to the time the filaments are finally deposited onto the screen 3 and carried under the bottom surface 35 of the jet unit 2. As is more fully discussed in the above mentioned U.S. Patent 3,457,611, to which reference is made, crimping in the disclosed apparatus is believed to occur essentially when the filaments are folded onto the screen 3, with the vertical components of the folds being compressed when the filaments pass under the bottom surface 35 of the jet unit 2.

WHAT WE CLAIM IS:—

1. A process for simultaneously fibrillating a film to form continuous filaments and bulking the resulting filaments, characterized by the steps of: providing a ribbon of longitudinally oriented thermoplastic film having striations extending lengthwise thereof in a parallel and equally spaced arrangement, with the striations interconnected laterally by webs of reduced thickness; feeding the ribbon endwise positively at a predetermined speed; forming a jet from a fluid at a temperature sufficient to soften the ribbon without loss of orientation, with the jet surrounding the ribbon and moving the same endwise therewith at a predetermined speed; directing the fluid jet and the ribbon into the chamber having an open end opposed to the fluid jet and a cross-sectional area sufficient to permit limited lateral movement of the fluid jet; and moving a screen at a speed substantially less than the above predetermined speed laterally across, and in close proximity to, the open end of the chamber for confining the fluid jet to exhaust from the chamber through the screen, whereby the ribbon is fibrillated into continuous filaments which are folded onto but unequally deposited on the screen, thereby diverting the fluid jet from the more dense to the less dense areas of filament deposition and resulting in deflection of the jet and thus the ribbon within the chamber in a random manner and at a rapid rate, and whereby the filaments on the screen are compressed against the screen as they are moved on the surface of the screen from the area of the chamber.

2. A process for simultaneously fibrillating a film to form continuous filaments and bulking the resulting filaments, substantially as described hereinabove, with reference to, and as shown in, Figures 1 and 2 of the accompanying drawings.

3. A process for simultaneously fibrillating a film to form continuous filaments and bulking the resulting filaments, substantially as described in the foregoing Example.

4. Bulked filaments whenever produced by the process claimed in any one of the preceding claims.

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1267298 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

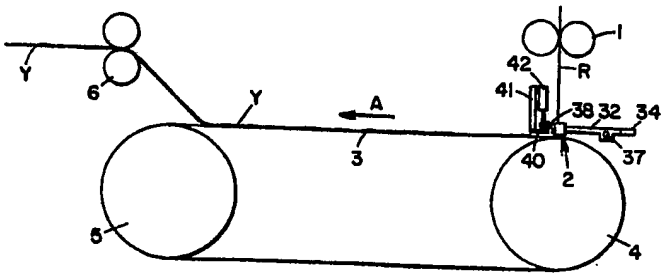

FIG. 1

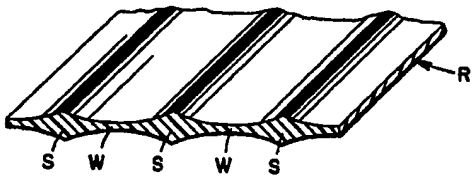

FIG. 3

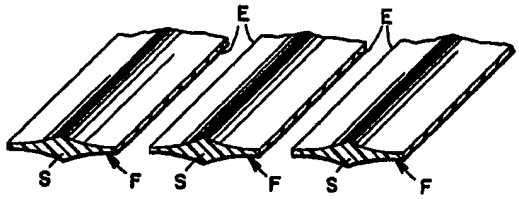

FIG. 4

1267298 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 2

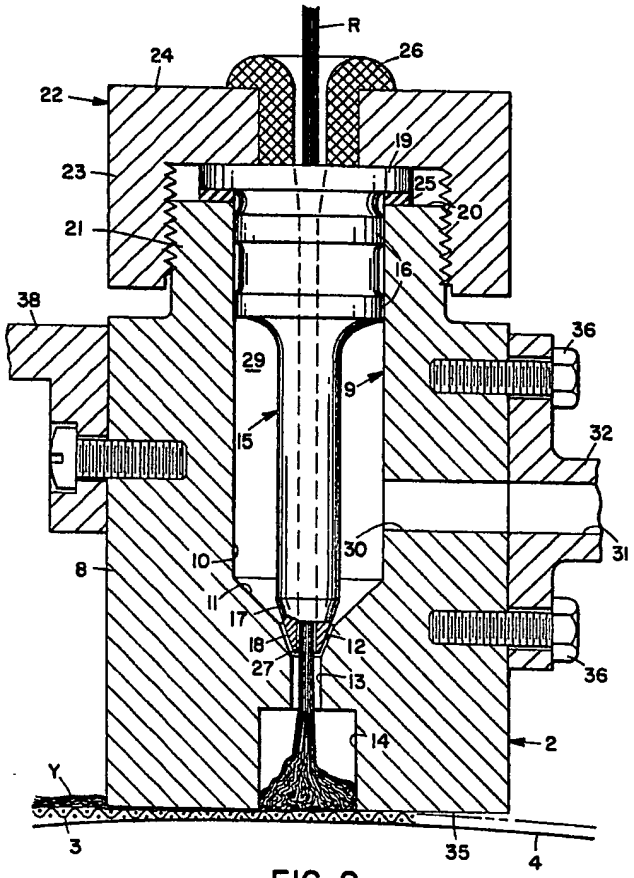

FIG. 2